BACKGROUND OF THE INVENTION

The present invention relates to a combustion-engined setting tool of the type described in the preamble of Claim 1. Such setting tools can operate on gaseous or liquid fuels which are combusted in the combustion chamber and, thereby, drive a setting piston for fastening elements.

Generally, there exists a problem of admixing, for each operational cycle, a proper amount of air or oxygen, which is used as oxidation means, to the fuel. In particular, air, when taken from a surrounding environment, is subjected to pressure and temperature fluctuations which can unfavorably influence the combustion of the air-fuel mixture, in particular when the fuel content in the mixture is too large or too small.

European Publication EP 0 597 241 B1 discloses a combustion-engined setting tool in which fuel is fed from a fuel source to the combustion chamber through a normally-closed solenoid valve. The excitation is effected electronically, with a switching circuit which responds to closing of an actuation switch and opens the valve for a predetermined adjustable time period to enable a fuel flow from the fuel source into the combustion chamber. The drawback here consists in that the process of filling the combustion chamber starts only after the tool has been pressed against a constructional component and when the switch is

actuated. This leads, in particular at low environmental temperatures, to a noticeable time delay which is contrary to a rapid operation.

German Publication DE 42 43 617 A1 discloses a combustion-engined setting tool in which during an operational cycle, a gas inlet valve is mechanically opened so that fuel flows from a fuel source into a storage chamber that communicates with the environment. Due to this communication, the pressure and, if necessary, the temperature can be balanced with the environmental air, so that a proper air-fuel mixture reaches the combustion chamber. The mixture is fed from the storage chamber into the combustion chamber by a predetermined time. The drawback here consists in possible fuel losses because of the communication with environment.

Accordingly, an object of the present invention is to provide a setting tool of the type described above in which the above-mentioned drawbacks are eliminated and rapidly following one another, setting processes can be effected at an optimal fuel metering. This is achieved with features set forth in Claim 1 of which the following are particularly important.

It is sufficient when in the fuel feeding guide, between the electronically controlled valve and the combustion chamber, there is provided a storage chamber that has no communication with the environment. This storage chamber is filled with fuel, through the electronically controlled valve, before the setting tool is

pressed against a constructional component and provides for rapidly following one another, setting processes. In response to the setting tool being pressed against a constructional component, the storage chamber is connected with the combustion chamber by preferably mechanical actuation means, so that a precisely metered volume of fuel is fed into the combustion chamber. With these measures, a rapid operation of the setting tool with precise metering of fuel becomes possible. The electronically controlled valve enables a precise metering of fuel in its liquid phase. In the storage chamber, preferably, the fuel is stored in a gaseous phase.

Advantageously, the electronically controlled valve is open for the predetermined time period by the control unit in response to opening of the preferably electronic actuation means upon lifting of the setting tool off the constructional component. In this way, the valve opens by an earlier point in time, namely, when the setting tool is being lifted off a constructional component, and the storage chamber is filled again.

According to a further advantageous embodiment of the inventive setting tool, a piston is dispeaceably arranged in the storage chamber and is displaced by the mechanical actuating means, forcing the fuel from the storage chamber and into the combustion chamber. Thereby, delivery of an entire fuel volume, which is stored in the storage chamber, is insured.

It is further advantageous when a check valve is arranged in the fuel guide between the storage chamber and the combustion chamber, and becomes opens in response to a delivery displacement of the piston against a biasing force. These measures insure that the fuel in the storage chamber would not flow prematurely into the combustion chamber, and no blow-back occurs when the fuel-air mixture in the combustion chamber is ignited.

According to a further advantageous embodiment of the setting tool, a shuttle valve is arranged in the fuel line between the valve and the storage chamber, on one hand, and between the storage chamber and the combustion chamber on the other hand, and is retained by preferably mechanical actuating means, in the initial position of the mechanical actuating means, in a first switching position in which fuel deliver from the storage chamber to the combustion chamber is interrupted and the electronically controlled valve communicates with the storage chamber, and is retained, in the actuated position of the mechanical actuating means, in a second switching position in which fuel flow between the storage chamber and the electronically controlled valve is interrupted and the storage chamber is connected with the combustion chamber. With the shuttle valve, there is provided a setting tool which can be easily produced and in which the fuel flows from the storage chamber into the combustion chamber as a result of pressure existing in the storage chamber.

Advantageously, a check valve is provided between the shuttle valve and the combustion chamber which opens, against a biasing force, by the fuel pressure in the storage chamber. This measure insures that no blow-back occurs when the air-fuel mixture is ignited in the combustion chamber.

In order to adapt the amount of fuel, which is fed into the combustion chamber to parameters of the surrounding environment, *e.g.*, temperature, air pressure, air humidity and to operational conditions of the setting tool, there is provided sensor means for detecting the operational conditions and the parameters and for converting them into electronic signals. The acquired data are transmitted by appropriate data transmitting means to the control unit in which based on these data or parameters, the optimal amount of fuel for an operational cycle or a setting process is determined. The sensor means can be formed, e.g., as sensors.

Advantageously, the electronically controlled valve is formed as a solenoid valve. This measure insures that the valve exactly follows the control command of the control unit and also provides for a cost-effective construction of the setting tool.

Advantageously, the control unit includes a data processing unit formed, *e.g.*, as a microprocessor or the like, or includes same. This measure insures a quick processing of the input data and requires a reduced constructional space.

Further advantages and features follow from the subclaims, description, and the drawings. The drawings show two embodiments of the invention.

The drawings show:

Fig. 1 a partially cross-sectional view of a setting tool according to the present invention in an initial position thereof;

Fig. 2 the setting tool in Fig. 1 but with the setting tool being slightly pressed against a constructional component;

Fig. 3 the setting tool in Fig. 1 but with the setting tool being completely pressed against the constructional component and with the setting process being actuated;

Fig. 4 the setting tool in Fig. 1 but with the setting tool being lifted off of the constructional component; and

Fig. 5 another embodiment of a setting tool according to the present invention in an initial position thereof.

Figs. 1-4 show a first embodiment of the combustion-engined setting tool 10 according to the present invention.

The setting tool 10 is shown in Fig. 1 in its initial or off position. The setting tool 10 is operated with a fuel gas. The setting tool 10 has a housing 30 in which a setting mechanism is located with which a fastening element such as, *e.g.*,

a nail, a bolt, or the like, can be driven in a constructional component (not shown in Fig. 1) when the setting tool 10 is pressed against the constructional component and is actuated.

The setting mechanism includes, among others, a combustion chamber 13, a piston guide 17 in which a drive piston 16 is displaceably arranged, and a bolt guide 18 for a fastening element and in which the fastening element is displaceable by a forward movable, setting direction end of the drive piston 16 and thereby can be driven in the constructional component. Fastening elements are usually stored, *e.g.*, in a magazine 19 attachable to the setting tool 10.

In the present embodiment, in the combustion chamber 13, there is arranged an ignition unit, *e.g.*, a spark plug 23, for igniting an air-fuel mixture fed into the combustion chamber 13 for effecting a setting process. Feeding of fuel into the combustion space or the combustion chamber 13 is effected through a fuel guide 12, *e.g.*, a fuel conduit, from a fuel reservoir or a fuel source 11. In the fuel guide 12, there are arranged in a row, one after another, and downstream of each other, an electronically controlled valve, *e.g.*, a piezoelectrical valve or a solenoid valve 24, a storage chamber 21, and a check valve 34.1.

In the storage chamber 21, a piston 14.1 is displaceably arranged. With the piston 14.1, a fuel volume, which fills the storage chamber 21, can be forced out therefrom. To this end, the piston 14.1 is connected by mechanical shifting

means 15.1, *e.g.*, an actuating linkage, with actuating means 15, *e.g.*, an end actuator, arranged in a region of the bolt guide 18 of the setting tool 10.

The inventive setting tool further comprises an electronic control unit 20 which is connected with a power source 27, *e.g.*, a battery or an accumulator, by an electrical conductor 47.

The control unit 20 is provided with data processing means 29, *e.g.*, a microprocessor in which a control program for one or several of tool functions can be executed. The control unit 20 controls metering of fuel by controlling the operation of the electronically controlled valve 24.

The control unit 20 is connected with the electronically controlled valve 24 by an electrical conductor 44. An electrical conductor 43 connects the control unit 20 with the ignition unit 23. The end actuator or the actuating means 15 cooperates with an electronic actuation means 25 that is connected with the control unit 20 by an electrical conductor 46. An actuation switch 35, which is arranged on a handle of the setting tool 10, is connected with the control unit 20 by an electrical conductor 45. Further, the control unit 20 processes measurement data and parameters generated by sensor means 22.1, 22.2, *e.g.*, a sensor for determining an air pressure or air humidity. The sensor means 22.1, 22.2 is connected with the control unit 20 by electrical conductors 41, 42. The electrical

conductors 41, 42, 43, 44, 45, 46, 47 serve for both feeding electrical energy and transmitting electronic data.

In the initial or off position of the setting tool 10, which is shown in Fig. 1, the electronically controlled valve 24 is closed, and the storage chamber 21 is filled with a predetermined volume of gaseous fuel. However, the fuel cannot yet flow into the combustion chamber 13 as the check valve 34.1 is also closed.

In Fig. 2, the setting tool 10 is placed on a constructional component U, and the end actuator or the actuating means 15 has been displaced along a first path (in a direction of arrows 54, from Fig. 1) into the setting tool 10. The displacement of the actuating means 15 is transmitted to the piston 14.1 via shifting means 15.1, whereby the piston 14.1 is also displaced along a corresponding path, and its displacement leads to reduction of the inner volume of the storage chamber 21 so that pressure in the storage chamber increases and the check valve 34.1 opens. Only now the fuel can flow into the combustion chamber 13 in the flow direction 26 through the open check valve 34.1.

In Fig. 3, the setting tool 10 is completely pressed against the constructional component U. The actuating means 15 has been displaced over the entire shifting path, and the piston 14.1 forced out the entire volume of fuel from the storage chamber 21 through the check valve 34.1 and into the combustion chamber 13. Simultaneously, the electronic actuation means 25 is actuated or closed by the

shifting means 15.1. This actuation is communicated to the control unit 20 via the electrical conductor 46. The actuation switch 35 is actuated by a tool operator, with the actuation signal being transmitted via the electrical conductor 45 to the control unit 20 where it is processed. In response, the control unit 20 generates an ignition signal which is transmitted via the electrical conductor 43 to the ignition unit 23 which ignites, at 28, the air-fuel mixture in the combustion chamber 13. In this phase, both valves 24 and 34.1 are closed.

In Fig. 4, the setting tool 10 has been lifted off the construction component U, whereby the actuating means 15 has been displaced by the first path in the direction of arrow 55. The mechanical shifting means 15.1 transmits the displacement of the actuating means 15 to the piston 14.1, and by this displacement, the volume of the storage chamber 21 has been increased. The mechanical shifting means 15.1 also opens electronic actuation means 25 which is monitored by the control unit 20 via the conductor 46. In response to opening of the actuation means 25, the control unit 20 generates a control signal which is transmitted by the conductor 44 to the electronically controlled valve 25, in response to which, the electronically controlled valve 24 opens for a time period preset by the control unit 20, and then closes again. This time period is determined by the control which unit 20 based on temperature and pressure information supplied by sensor means 22.1, 22.2 in order to achieve an optimal adaptation of

the amount of fuel. The fuel flows into the storage chamber 21 through a first section of the fuel guide 12 in the direction shown with arrow 26.1 where it is stored until the next setting step. After the setting tool 10 has been completely lifted off the constructional component U (Fig. 1), it is ready for a new setting process.

Fig. 5 shows another embodiment of a setting tool 10 according to the present invention in its initial or off position. This setting tool 10 differs in that a shuttle valve 14.2 is arranged in the fuel guide 12 between the storage chamber 21 and the electronically controlled valve 24 and which is operated by the actuating means 15 via the shifting means 15.1.

The shuttle valve 14.2 can be also arranged between the storage chamber 21 and the check valve 34.2 in the section of the fuel guide 12 leading to the combustion chamber. The storage chamber 21, in the embodiment shown in Fig. 5, does not include a plunger, though a plunger can be integrated thereinto.

In the off-position shown in Fig. 5, the shuttle valve 14.2 occupies a first switching position 52 in which it connects the storage chamber 21 with the electronically controlled valve 24. In the position shown in Fig. 5, the electronically controlled valve 24 is in its closed position.

Upon pressing of the setting tool 10 against a constructional component in the direction of arrow 54, the actuating means 15 and the shifting means 15.1

displace the shuttle valve 14.2 to its second position 53 in which the check valve 34.2 connects the storage chamber 21 with the combustion chamber 13. The check valve 34.2 is formed so that it opens as a result of pressure in the storage chamber 21 when the shuttle valve 14.2 connects the storage chamber 21 with the check valve 34.2.

In a press-on condition of the setting tool 10 (not shown), the actuation means 25 is closed, and ignition can take place in response to the ignition signal generated by the control unit 20 when an operator of the setting tool 10 actuates the actuation switch 35.

Upon lifting of the setting tool 10 off the constructional component (not shown), a reset spring displaces the shuttle valve 14.2 to its initial position 52 in which the shuttle valve 14.2 connects the storage chamber 21 with the electronically controlled valve 24. Simultaneously, the actuation means 25 opens again and the opening is transmitted via the conductor 46 to the control unit 20 which opens, via the conductor 44, the electronically controlled valve 24 for a predetermined time period. Again, the time period is calculated by the control unit 20 dependent on parameters detected by sensor means 22.1, 22.2. For further details which are not described here, reference should be made to the description of Figs. 1-4.

LIST OF REFERENCE NUMBERALS

10. Setting Tool

11. Source of fuel

12. Fuel guide

13. Combustion chamber

14.1. Piston

14.2 Shuttle valve

15. Actuating means (mechanical)

15.1. Mechanical shifting means from 15 to 14.1/14.2

16. Drive piston

17. Piston guide

18. Bolt guide

19. Magazine

20. Control unit

21. Storage chamber

22.1 Sensor means

22.2 Sensor means

23. Ignition unit

24. Valve (electronic)

25. Actuation means (electronic)

26. Fuel flow direction

26.1 Arrow

27. Power source

28. Ignition

29. Data processing unit

30. Housing

34.1. Check valve

34.2. Check valve

35. Actuation switch

41. Electrical conductor (between 20 and 22.1)

42. Electrical conductor (between 20 and 22.2)

43. Electrical conductor (between 20 and 23)

44. Electrical conductor (between 20 and 24)

45. Electrical conductor (between 20 and 35)

46. Electrical conductor (between 20 and 25)

52. First switching position (of the shuttle valve 14.1)

53. Second switching position (of the shuttle valve 14.1)

54. Direction of an arrow

55. Direction of an arrow
U constructional component

CLAIMS

1. A combustion-engined setting tool for driving in fastening elements such as nails, bolts, pins in a constructional component,

with a fuel source (11),

with a fuel guide (12) from the fuel source to the combustion chamber (13), and with at least one electronically controlled valve (24) which is arranged in the fuel guide (12) between the fuel source (11) and the combustion chamber,

and with a control unit (20), finally with at least one actuation means (25) that open the valve (24) for a time period,

characterized in that the fuel guide (12), a storage chamber (21) is arranged between the electronically controlled valve (24) and the combustion chamber (13).

2. As setting tool according to Claim 1, characterized in that the electronically controlled valve (24) is opened by the control unit (20) for a predetermined time period in response to opening of an actuation means (25) upon lifting of the setting tool (10) off a constructional component (U).

3. A setting tool according to claim 1 or 2, characterized in that in the storage chamber (21), a piston (14.1) dispeaceable in response to actuation of actuating means (15), is dispeaceably arranged.

4. A setting tool according to Claim 1 or 3, characterized in that in the fuel guide (12) between the storage chamber (21) and the combustion chamber (13), a check valve (34.1) is arranged.

5. A setting tool according to Claim 1 or 2, characterized in that in the fuel guide (12) between the electronically controlled valve (24) and the storage chamber (21), on one hand, and between the storage chamber (21) and the combustion chamber (13), on the other hand, a shuttle valve (14.2) is arranged which is retained by the actuating means (15) in a first switching position(52) in the initial position of the actuating means (15) and in which the fluid flow in the fuel guide from the storage chamber (21) to the combustion chamber (13) is interrupted and the electronically controlled valve (24) communicates with the storage chamber (21), and is retained, in the actuation position of the actuating means (15), in a second switching position (53) in which the fuel flow in the fuel guide (12) between the storage chamber (21) and the electronically controlled valve (24) is interrupted and the storage chamber (21) communicates with the combustion chamber (13).

6. A setting tool according to Claim 1 or 5, characterized in that a check valve (34.2) is arranged between the shuttle valve (14.2) and the combustion chamber (13).

7. A setting tool according to Claim 1 or 2, characterized in that sensor means (22.1, 22.2) for sensing air pressure, temperature, and air humidity are provided and which are connected with the control unit (20) by data conductors (41, 42)

8. A setting tool according to one of Claims 1 through 7, characterized in that the electronically controlled valve (24) is a solenoid valve.

9. A setting tool according to one of Claims 1 through 8 characterized in that the control unit (20) includes a data processing unit (29) for evaluation an processing of the emitted sensor data.